

While certain representative embodiments and details have been shown for purposes of illustrating the invention, it will be apparent to those skilled in the art that various changes in the methods and apparatus disclosed may be made without departing from the scope of the invention, which is defined in the appended claims.

What is claimed is:

1. A micropore open cell foam composite comprising an open cell foam having an open cell content of 80% or more and an average pore size of about 1 to 200 microns and a phase change material wherein the phase change material is present in the open cell
5 foam in the amount of 80% volume or greater.

2. The micropore open cell foam composite of claim 1 wherein the open cell micropore foam has an open cell content of 90% or more and the phase change material is present in the open cell foam in the amount of 90% volume or greater.

3. The micropore open cell foam composite of claim 2 wherein the micropore open cell foam has an open cell content of 95% or more and the phase change material is present in the open cell foam in the amount of 95% volume or greater.

4. The micropore open cell foam composite of claim 1 wherein the phase change material comprises an organic linear, crystalline alkyl hydrocarbon or mixture thereof having an average carbon chain length of at least 8 carbon atoms and a
5 phase change temperature between -40°C and 132°C.

5. The micropore open cell foam composite of claim 4 wherein the linear, crystalline alkyl hydrocarbon phase change material has an average carbon chain length of about 12 to 18 carbon atoms and a phase change temperature between 0°C and 30°C.

6. The micropore open cell foam composite of claim 5 wherein said phase change material is a mixture comprising hexadecane, pentadecane, and tetradecane.

7. The micropore open cell foam composite of claim 6 wherein said phase change material comprises about 45 to 50 weight

percent hexadecane, about 30 to 35 weight percent tetradecane,
and about 15 to 25 weight percent of a mixture of N-paraffins
5 having an average chain length of about 15 carbon atoms.

8. The micropore open cell foam composite of claim 7 wherein
said phase change material comprises about 48 weight percent
hexadecane, about 32 weight percent tetradecane, and about 20
weight percent of a mixture of n-paraffins having an average
5 chain length of about 15 carbon atoms.

9. The micropore open cell foam composite of claim 1 wherein
said phase change material further comprises an antioxidant in a
concentration of about 0.1 to 1 weight percent.

10. The micropore open cell foam composite of claim 1 wherein
the phase change material is selected from the group consisting
of fatty acids, fatty acid esters, primary alcohols, ethylene
glycol copolymers, polyethylene oxide and polyethylene.

11. The micropore open cell foam composite of claim 1 wherein
the phase change material is selected from the group consisting
of water, water/urea, water/salt, water/glycerine, water/salt
hydrates, and quaternary ammonium clathrates and semi-clathrates.

12. The micropore open cell foam composite of claim 11 wherein
the phase change material is a water/salt hydrate, wherein the
salt hydrate is selected from the group consisting of sodium
sulfate decahydrate, calcium chloride hexahydrate, trisodium
5 phosphate dodecahydrate, disodium monohydrogen phosphate
dodecahydrate, and sodium acetate trihydrate.

13. The micropore open cell foam composite of claim 1 wherein
the phase change material further comprises a soluble polymeric

thickening agent wherein said thickening agent is present in an amount of about 0.1 to 10% based on the weight of the phase change material.

14. The micropore open cell foam composite of claim 13 wherein said phase change material is an organic phase change material and said polymeric thickening agent is selected from the group consisting of styrene/butadiene random and block copolymers, polybutadiene, polyisoprene, polyisobutylene polymers and copolymers, ethylene/propylene copolymers, polymethyl methacrylate polymers, and low and high density polyethylenes.

15. The micropore open cell foam composite of claim 13 wherein the phase change material is a polar water-based composition and the polymeric thickening agent is selected from the group consisting of polyvinyl alcohol, polyethylene glycol, polyethylene oxide, polyacrylic acid, polymethacrylate acid and vinyl acetate/maleic acid copolymers.

16. The micropore open cell foam composite of claim 1 wherein said open cell foam composite is packaged in an impermeable envelope wherein said impermeable envelope is sealed around the open cell foam composite thereby forming an enclosed micropore open cell foam composite.

17. The micropore open cell foam composite of claim 16 wherein said enclosed micropore open cell foam composite is evacuated to a pressure of 100 torr or less.

18. The micropore open cell foam composite of claim 1 wherein the phase change material comprises a liquefied gas.

19. The micropore open cell foam composite of claim 18 wherein said liquefied gas is selected from the group consisting of liquid nitrogen, helium, carbon dioxide, air and mixtures thereof.

20. The micropore open cell foam composite of claim 1 wherein the phase change material is solid carbon dioxide.

21. A process for manufacturing the micropore open cell foam composite of claim 1 comprising the steps of:

- (a) placing the micropore open cell foam in an enclosure;
- (b) evacuating the enclosure to a pressure of 10 torr or less;
- (c) introducing a supply of liquid phase change material into the enclosure; and
- (d) allowing the liquid phase change material to be drawn into the open cell foam.

22. The process of claim 21, wherein the enclosure in step (a) is evacuated in step (b) to a pressure of 1 torr or less.

23. A process for manufacturing the micropore open cell foam composite of claim 1 comprising the steps of:

- (a) providing an open cell foam slab having a plurality of sides;
- (b) enclosing all but one of the sides of the open cell foam in a metal mold; and
- (c) injecting a liquid phase change material under pressure through a port in one of the enclosed sides until the liquid phase change material emerges from the one open side.

24. A process for manufacturing the micropore open cell foam composite of claim 1 comprising the steps of:

- (a) providing a volume of liquid phase change material;
- (b) immersing the micropore open cell foam in the liquid phase change material.

25. The process of claim 24, wherein the phase change material is a liquefied gas.

26. The process of claim 25, wherein the liquefied gas is selected from the group consisting of liquid nitrogen, oxygen, carbon dioxide, helium, air and mixtures thereof.

27. The process of claim 24, wherein said volume of liquid phase change material is provided in a pressure vessel and further comprising the step of:

- (c) applying a gas pressure of 15 psi or greater to the interior of the vessel to load the micropore open cell foam with the liquid phase change material.

28. A system for storing and transporting temperature-sensitive materials comprising an insulated shipping container having disposed therein a micropore open cell foam composite, said micropore open cell foam composite comprising an open cell foam having an open cell content of about 80% or more and an average pore size of about 1 to 200 microns and a phase change material wherein the phase change material is present in the open cell foam in the amount of about 80% volume or greater.

29. The system of claim 28 wherein said system , wherein said system is capable of maintaining the temperature of the

temperature-sensitive material below 18°C for over 60 hours at an environmental temperature of 24°C

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30. The system of claim 28 wherein the phase change material is an organic phase change material selected from the group consisting of linear crystalline alkyl hydrocarbons, fatty acids, fatty acid esters, primary alcohols, ethylene glycol copolymers, polyethylene oxide and polyethylene.

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31. The system of claim 30 wherein the organic phase change material further comprises a polymeric thickening agent in the amount of 1 to 10% by weight of the phase change material, wherein said thickening agent is selected from the group consisting of styrene/butadiene random and block copolymers, polybutadiene, polyisoprene, polyisobutylene polymers and copolymers, ethylene/propylene copolymers, polymethyl methacrylate polymers, and low and high density polyethylenes.

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32. The system of claim 28 wherein the phase change material is a polar water soluble material selected from the group consisting of water, water/urea, water/salt, water/glycerine, water/salt hydrates, and quaternary ammonium clathrates and semi-clathrates.

33. The system of claim 32 wherein the phase change material further comprises a thickening agent selected from the group consisting of polyvinyl alcohol, polyethylene glycol, polyethylene oxide, polyacrylic acid, polymethacrylate acid, and vinyl acetate/maleic acid copolymers wherein said thickening agent is present in a concentration of about 1 to 10% by weight of the phase change material.

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34. The system of claim 28 wherein said phase change material is a liquefied or solidified gas selected from the group consisting

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of nitrogen, oxygen, helium, carbon dioxide, air and mixtures thereof and said shipping container further comprises an integral gas vent to relieve pressure from evolving gas.

35. The system of claim 34 wherein said phase change material is solidified carbon dioxide.

36. A process for manufacturing an enclosed open cell foam composite comprising the steps of:

- (a) providing an open cell foam having an open cell content of 80% or more and having an average cell size of about 1 to about 200 microns;
- (b) enclosing the open cell foam in a heat-sealable, polymeric film;
- (c) evacuating the open cell foam-containing envelope;
- (d) charging the open cell foam with a phase change material;
- (e) repackaging the phase change material-loaded foam in an impermeable envelope;
- (f) evacuating the impermeable envelope containing the phase change material-loaded open cell foam composite; and
- (g) sealing the envelope containing the open cell foam composite.

37. The process of claim 36 wherein the phase change material comprises about 45 to 50 weight percent hexadecane, about 30 to 35 weight percent tetradecane, and about 15 to 25 weight percent of a mixture of n-paraffins having an average chain length of about 15 carbon atoms.

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38. The process of claim 36 wherein the phase change material further comprises a thickening agent in an amount of 0.1 to 10% based on the weight of the phase change material.

39. The process of claim 36 wherein the impermeable envelope containing the phase change material-loaded open cell foam composite in step (f) is evacuated to a pressure of 100 torr or less.